NPP All Hands Meeting

19 November 2015

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BROOKHAVEN NATIONAL LABORATORY

a passion for discovery

Office of Science
U.S. DEPARTMENT OF ENERGY

Agenda

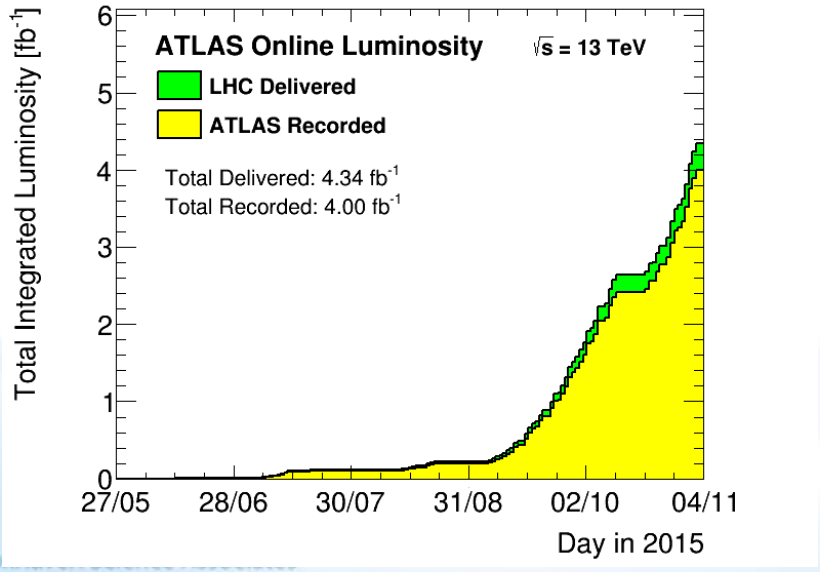
- HEP News: ATLAS, DUNE
- NP News: LRP, RHIC, EIC/eRHIC
- Other news (Safety, IO, SMD)
- OII Presentation (John Selva, Stasia Scocca)

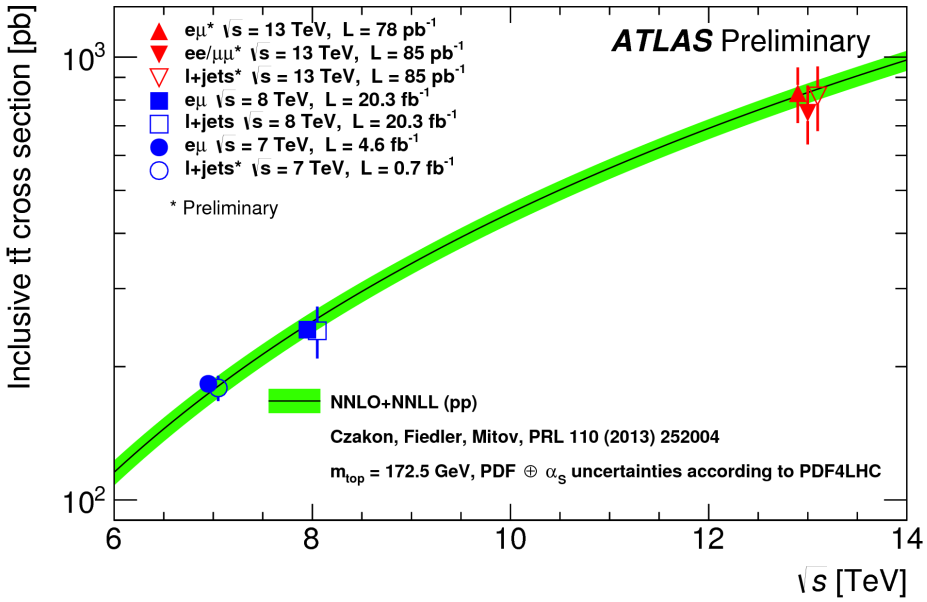
HEP News

Large Hadron Collider (LHC) and ATLAS Status

- The LHC and ATLAS are running very well – PbPb (pp) run starting
  - The LHC ran this year at 25 ns bunch crossing and 13 TeV
  - ATLAS has reported on many results - an example below

- 13 TeV opens a wider window of discovery for possible explanations of dark matter as well as precision measurements of the Higgs boson.
  - More results from the full 4 fb^{-1} will become public in about a month





BNL's Roles in the LHC and ATLAS

- Superconducting Magnet Division has built magnets for the LHC (and received a Secretary of Energy's award for it). We plan to continue building magnets for the Luminosity Upgrade.

- In ATLAS we have leading roles in physics analysis, operations, software and computing (the largest and most productive ATLAS Tier 1 computing center), and Upgrades for Phase I and Phase II.
  - We manage ATLAS Operations, Phase I Upgrade, and expect to be chosen to manage Phase II Upgrade
  - Phase II project is being defined in accordance with funding plans of DOE and NSF - >$150M

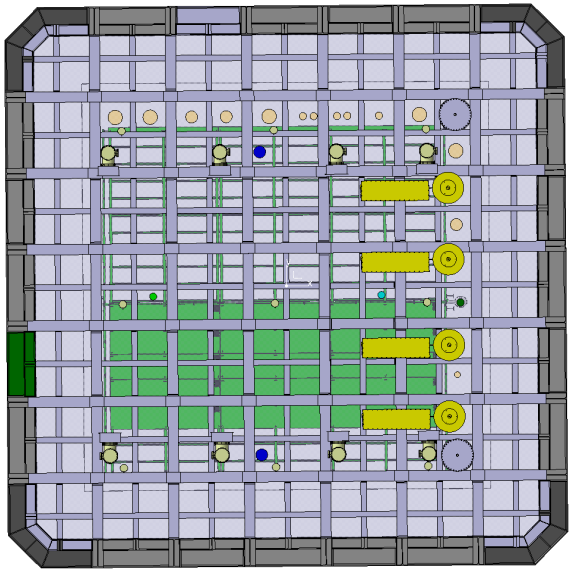
DUNE Status

DEEP UNDERGROUND NEUTRINO EXPERIMENT

- Collaboration has organized over last year based on LBNE foundation laid by BNL - Significant progress.
  - CD-1 (refresh) : 40kT at 4850 approved by DOE 11/4/2015
  - CD-3a review: 12/2-4 for 4850 excavation start in 2017
  - ProtoDUNE (3 full scale APA/CPA): endorsed by CERN-SPSC Will run in new NA test beam in 2018.

- BNL has leading project management roles in DUNE (Kettell, Stewart,…)
- BNL scientists make major contributions to the design, science case, sensitivity, systematic errors, electronics, ProtoDUNE mechanical design, project management, event reconstruction and visualization

ProtoDUNE cryostat top view



The 2015 NSAC Long Range Plan

Long Range Plan Charge to NSAC

The new NSAC Long Range Plan (LRP) should articulate the scope and the scientific challenges of nuclear physics today, what progress has been made since the last LRP, and the impacts of these accomplishments both within and outside of the field. It should identify and prioritize the most compelling scientific opportunities for the U.S. program to pursue over the next decade and articulate their scientific impact. A national coordinated strategy for the use of existing and planned capabilities, both domestic and international, and the rationale for new investments should be articulated. To be most helpful, the LRP should indicate what resources and funding levels would be required (including construction of new facilities, mid-scale instrumentation, and Major Items of Equipment) to maintain a world-leadership position in nuclear physics research and what the impacts are and priorities should be if the funding available provides for constant level of effort from the FY 2015 President's Budget Request into the out-years (FY 2016-2025), with constant level of effort defined using the published OMB inflators for FY 2016 through FY 2025. A key element of the new NSAC LRP should be the Program's sustainability under the budget scenarios considered.

The extent, benefits, impacts and opportunities of international coordination and collaborations afforded by current and planned major facilities and experiments in the U.S. and other countries, and of interagency coordination and collaboration in cross-cutting scientific opportunities identified in studies involving different scientific disciplines should be specifically addressed and articulated in the report. The scientific

2015 Long Rang Plan - 1

RECOMMENDATION I

The progress achieved under the guidance of the 2007 Long Range Plan has reinforced U.S. world leadership in nuclear science. The highest priority in this 2015 Plan is to capitalize on the investments made.

- *Complete and run CEBAF 12 GeV upgrade*
- *Complete FRIB at MSU*
- *Targeted program in neutrinos and fundamental symmetries*
- *The upgraded RHIC facility provides unique capabilities that must be utilized to explore the properties and phases of quark and gluon matter in the high temperatures of the early universe and to explore the spin structure of the proton.*

2015 Long Rang Plan - 2

RECOMMENDATION III

We recommend a high-energy high-luminosity polarized Electron Ion Collider as the highest priority for new facility construction following the completion of FRIB.

The EIC will, for the first time, precisely image gluons in nucleons and nuclei. It will definitively reveal the origin of the nucleon spin and will explore a new Quantum Chromodynamics (QCD) frontier of ultra-dense gluon fields, with the potential to discover a new form of gluon matter predicted to be common to all nuclei. This science will be made possible by the EIC's unique capabilities for collisions of polarized electrons with polarized protons, polarized light ions, and heavy nuclei at high luminosity.

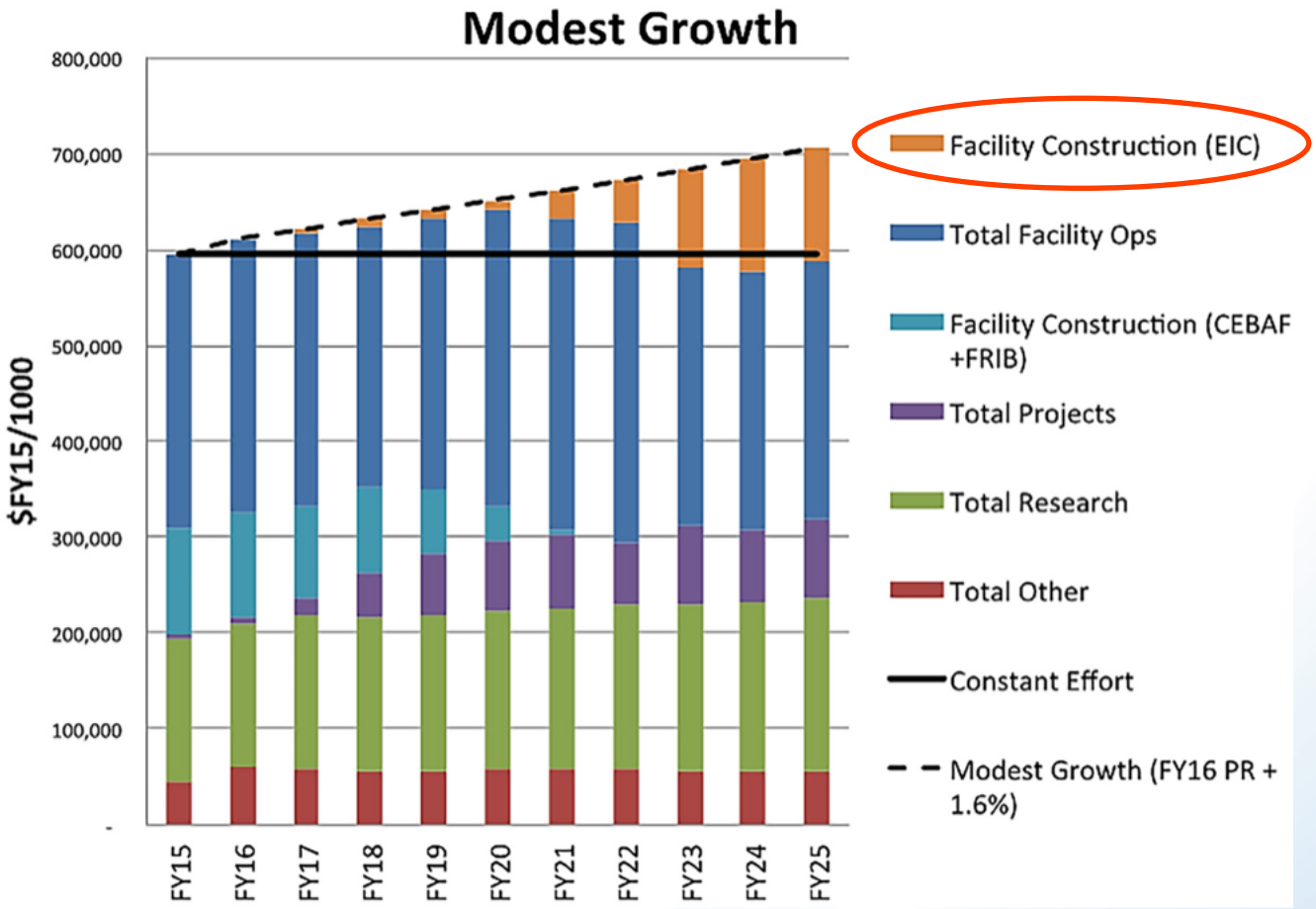
2015 Long Rang Plan - 3

Initiative for Detector and Accelerator

U.S. leadership in nuclear physics requires tools and techniques that are state-of-the-art or beyond. Targeted detector and accelerator R&D for the search for neutrinoless double beta decay and for the Electron Ion Collider is critical to ensure that these exciting scientific opportunities can be fully realized.

We recommend vigorous detector and accelerator R&D in support of the neutrinoless double beta decay program and the Electron Ion Collider.

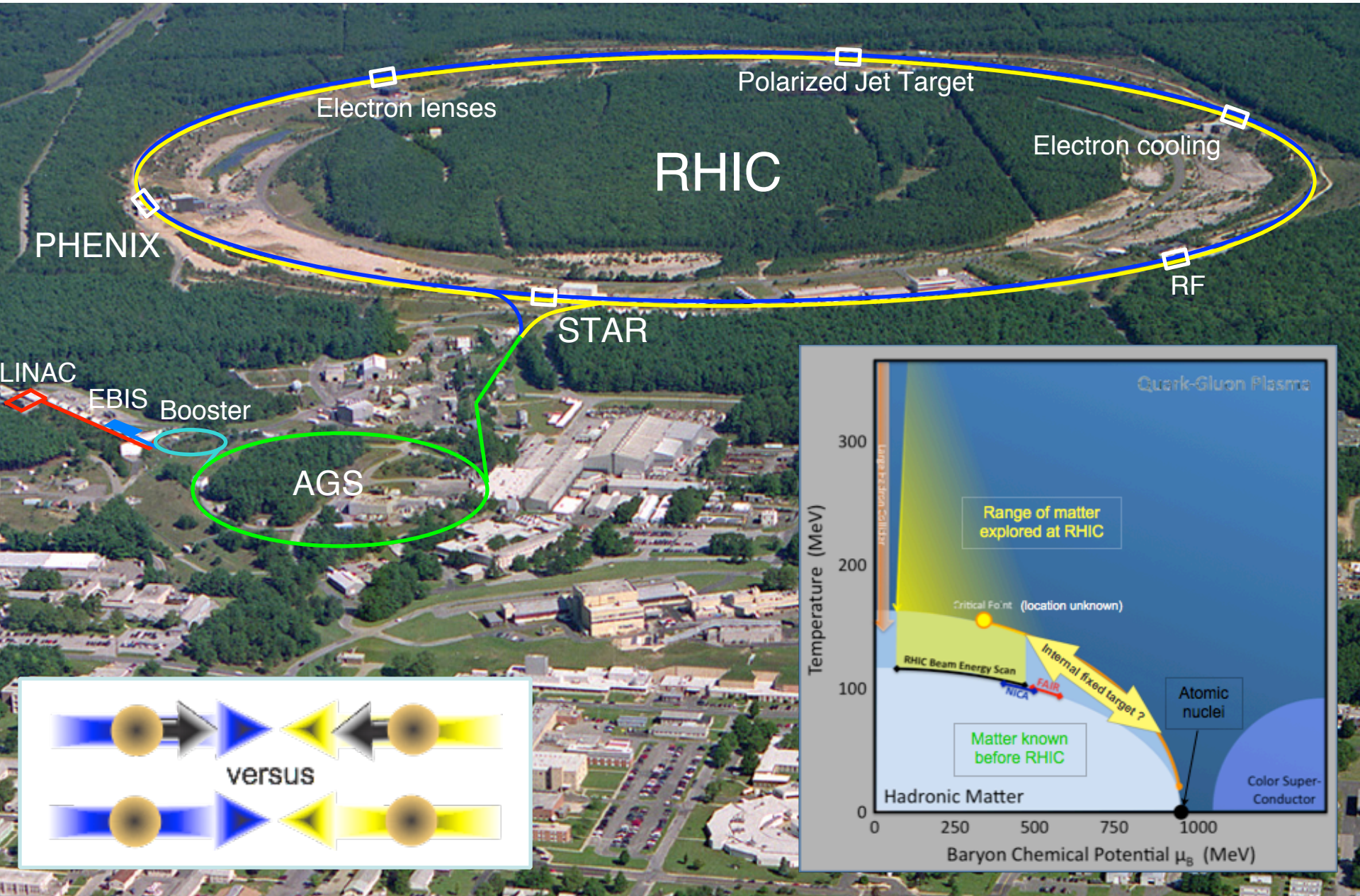
LRP Budget Scenario



EIC construction is made possible by end of FRIB construction and ramp down of RHIC operations after 2022 (maybe delayed to 2023).

Complete RHIC science mission

Relativistic Heavy Ion Collider



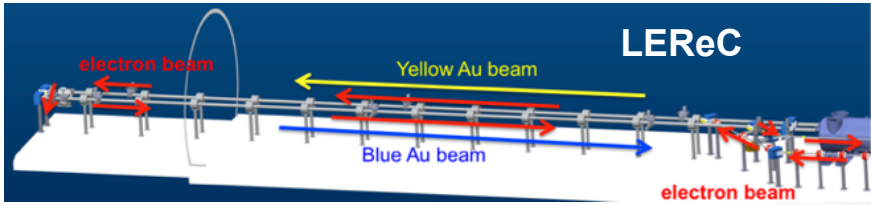
Completing the RHIC science mission

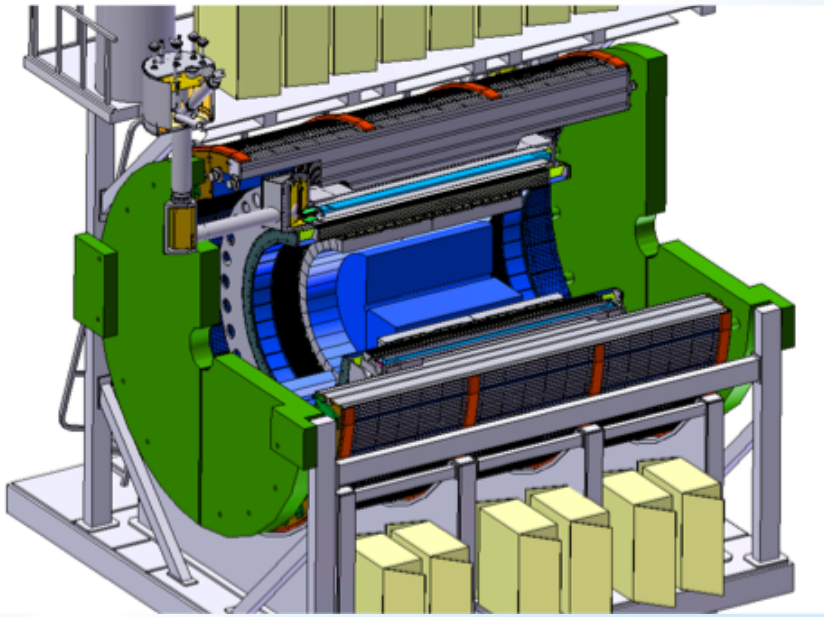
Status: RHIC-II configuration is complete

- Vertex detectors in STAR (HFT) and PHENIX
- Luminosity reaches 25x design luminosity

Plan: Complete RHIC mission in 3 campaigns:

- **2014–17: Heavy flavor probes of the QGP using the micro-vertex detectors; Transverse spin physics**
- *2018: Install low energy e-cooling*
- **2019/20: High precision scan of the QCD phase diagram & search for critical point**
- *Install sPHENIX*
- **Probe QGP with precision measurements of jet quenching and Upsilon suppression**
- **Spin physics and initial conditions at forward rapidities with p+p and p+A collisions ?**
- *Transition to eRHIC?*





RHIC remains a unique discovery facility

PHENIX/STAR

PHENIX plans to end data taking after Run 16.
Decommissioning anticipated starting in mid-2016.
Data analysis will continue for several more years.

STAR is critical for the success of Run 17 and BES-II in 2019/20. Important near-term upgrades:

- iTPC (with Chinese help – cost & schedule very challenging)
- STAR CBM TOF (GSI/FAIR contribution)
- Charge to STAR for opportunties after BES-II due October 19. Preliminary decision about possible upgrades by end of November 2015 after comments from PAC.

Updated RHIC Spin Plan requested by DOE

- Task Force formed and plan requested in January 2016

sPHENIX

A Large-Acceptance Jet and Upsilon Detector for RHIC

Collaboration formation process under way:

- Workshop held at BNL on June16, 2015 (J. Harris – Yale)
- More than 60 institutions have expressed interest
- Institutional Board formed on August 26, 2015
- By-Laws and spokesperson search committees formed
- First collaboration meeting December 10-12 at Rutgers

sPHENIX Project progress:

- Science case recommended in new NSAC LRP
- Successful science review by DOE on April 30, 2015
- PMG advising ALD meets weekly
- Preliminary CDR completed
- Director's cost and schedule review November 9-10

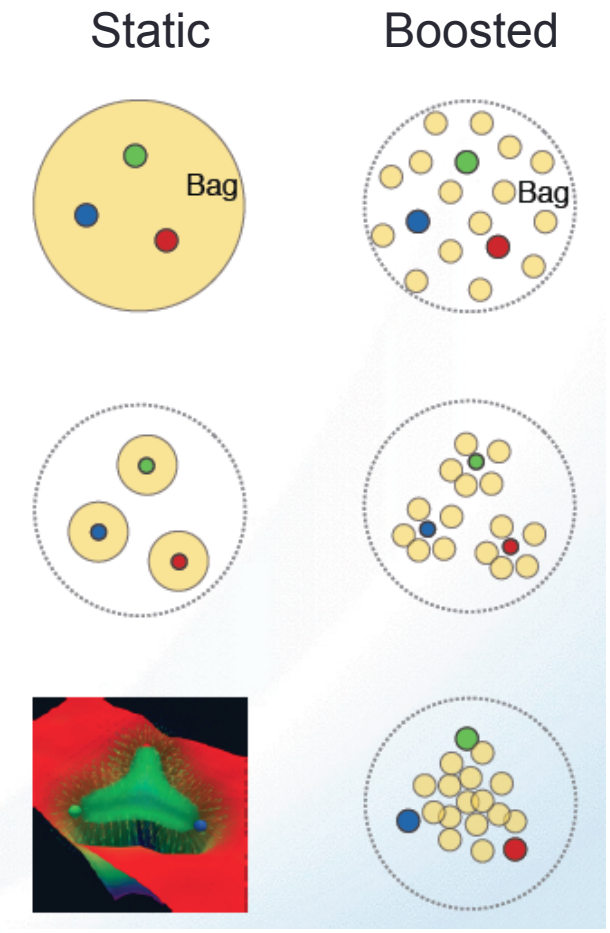
The Electron-Ion Collider (EIC)

The EIC Science Case

Gluons, the carriers of the strong force, bind the quarks together inside nucleons and nuclei and generate nearly all of the visible mass in the universe. Despite their importance, fundamental questions remain about the role of gluons in nucleons and nuclei. These questions can only be answered with a powerful new electron ion collider (EIC), providing unprecedented precision and versatility. The realization of this instrument is enabled by recent advances in accelerator technology.

The EIC will, for the first time, precisely image gluons in nucleons and nuclei. It will definitively reveal the origin of the nucleon spin and will explore a new quantum chromodynamics (QCD) frontier of ultra-dense gluon fields, with the potential to discover a new form of gluon matter predicted to be common to all nuclei. This science will be made possible by the EIC's unique capabilities for collisions of polarized electrons with polarized protons, polarized light ions, and heavy nuclei at high luminosity.

What does a proton look like?



Bag Model: Gluon field distribution is wider than the fast moving quarks.
Gluon radius > Charge Radius

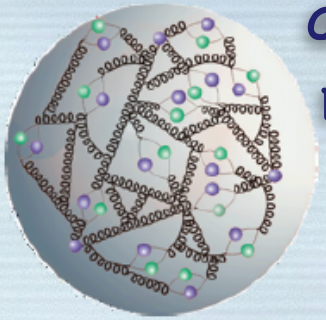
Constituent Quark Model: Gluons and sea quarks hide inside massive quarks.
Gluon radius ~ Charge Radius

Lattice Gauge theory (with slow moving quarks), gluons in between quarks:
Gluon radius < Charge Radius

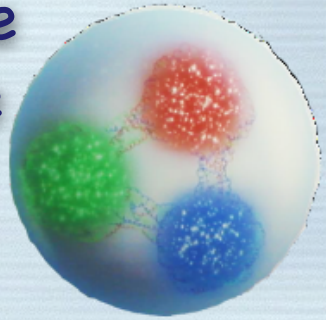
Need transverse images of the quarks and gluons in protons

The basic EIC concept

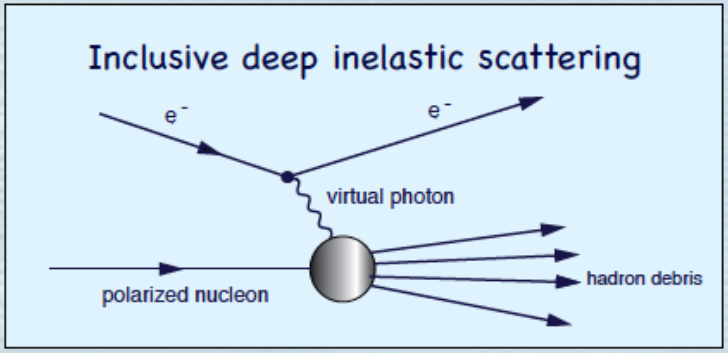
Deep Inelastic Scattering is somewhat like having a camera, with Bjorken-x being the shutter speed and Q^2 being the resolution scale

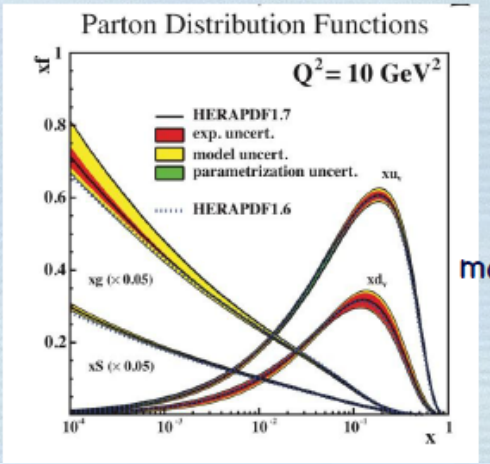


With x_{Bj} ~small
the things you hit are small:
short exposure time



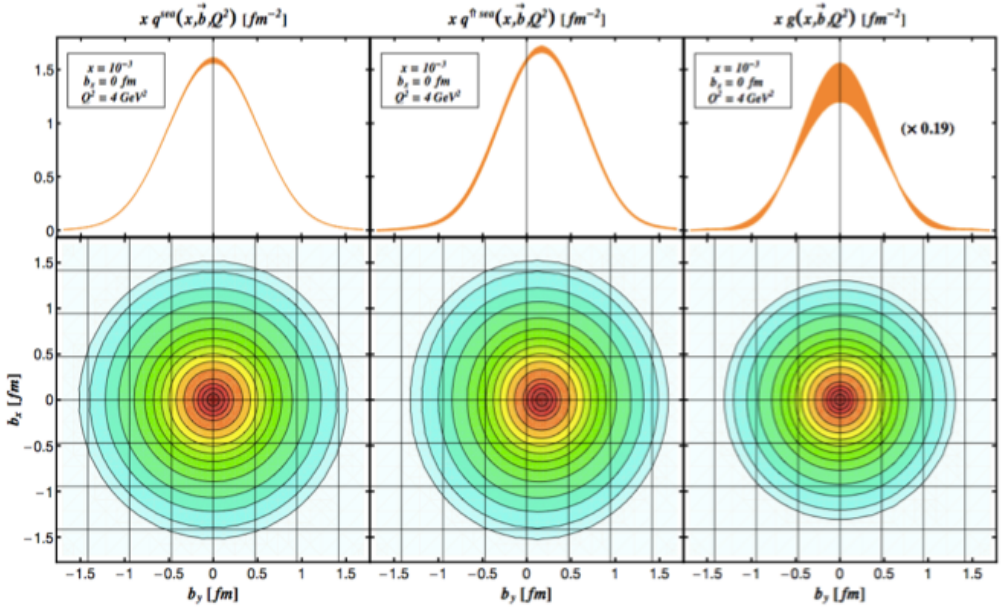
With x_{Bj} ~0.3
the things you hit are big:
long exposure time

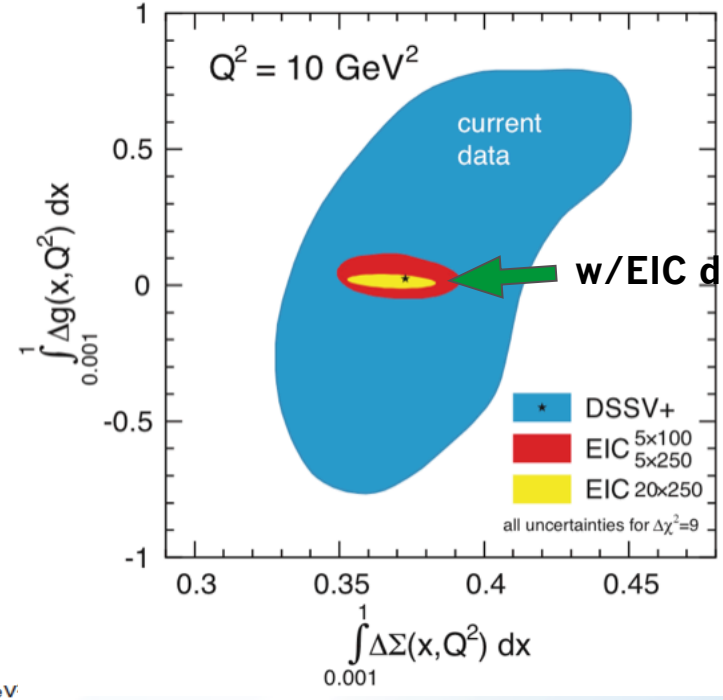


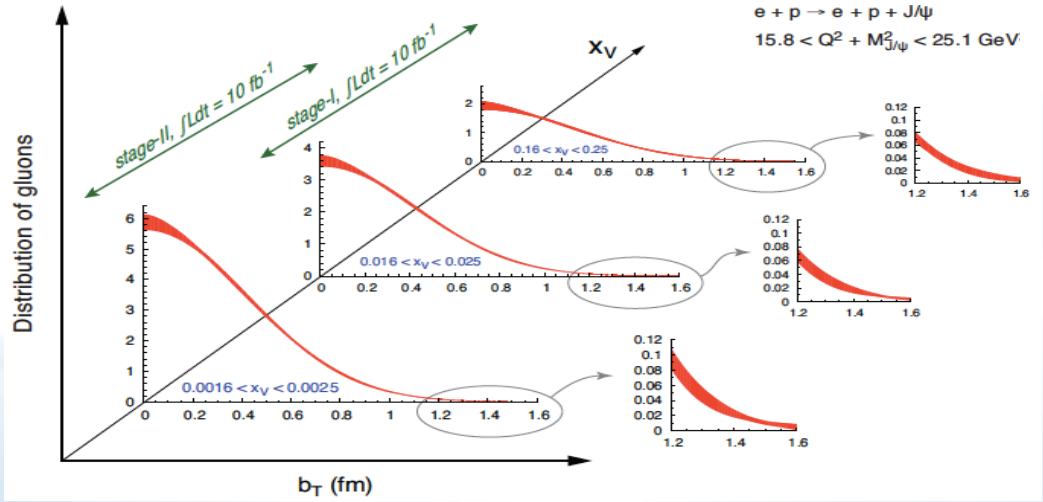


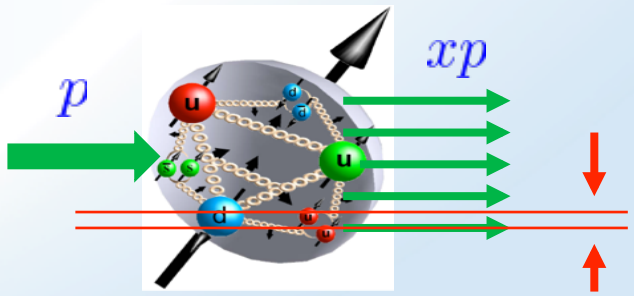
Longitudinal
(1-Dimensional)
momentum distribution
functions

Exquisite precision

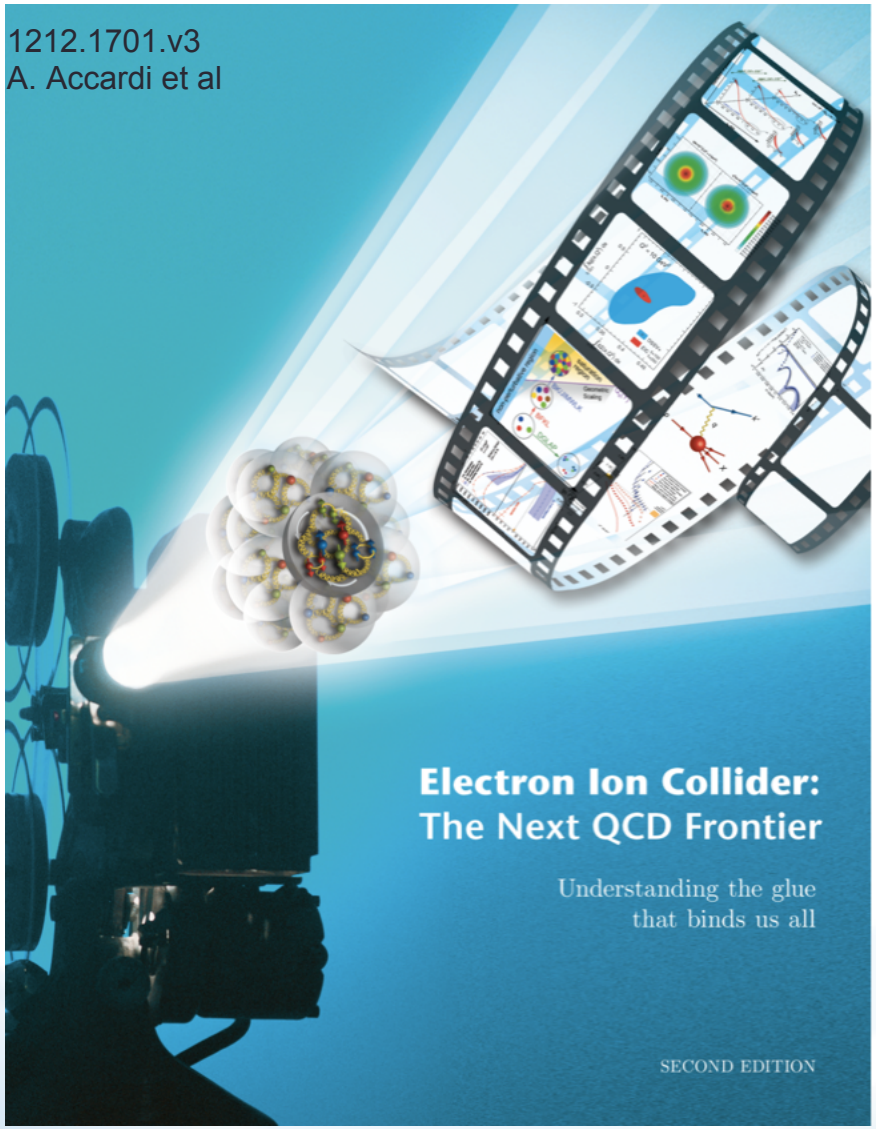




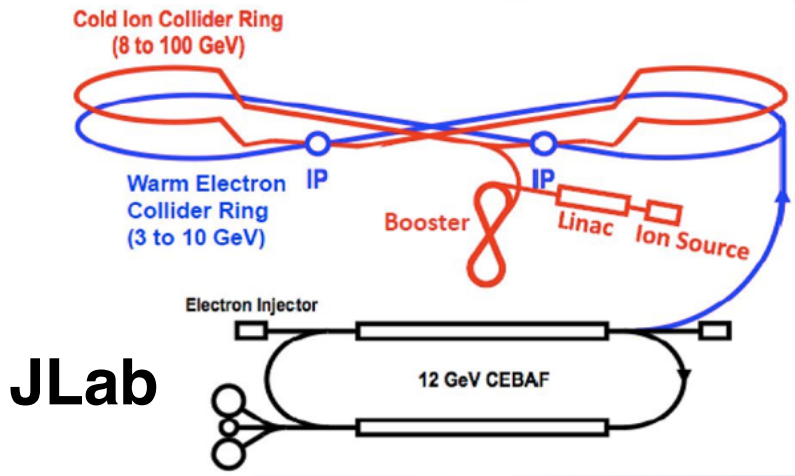




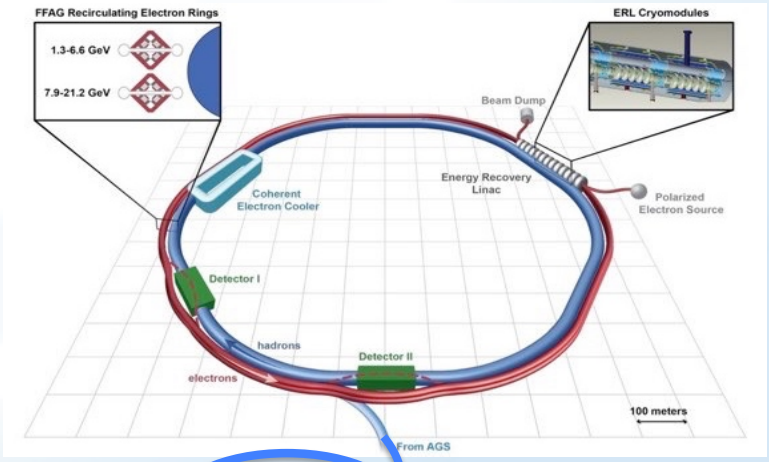
Electron Ion Collider



Two proposals for realizing the science case



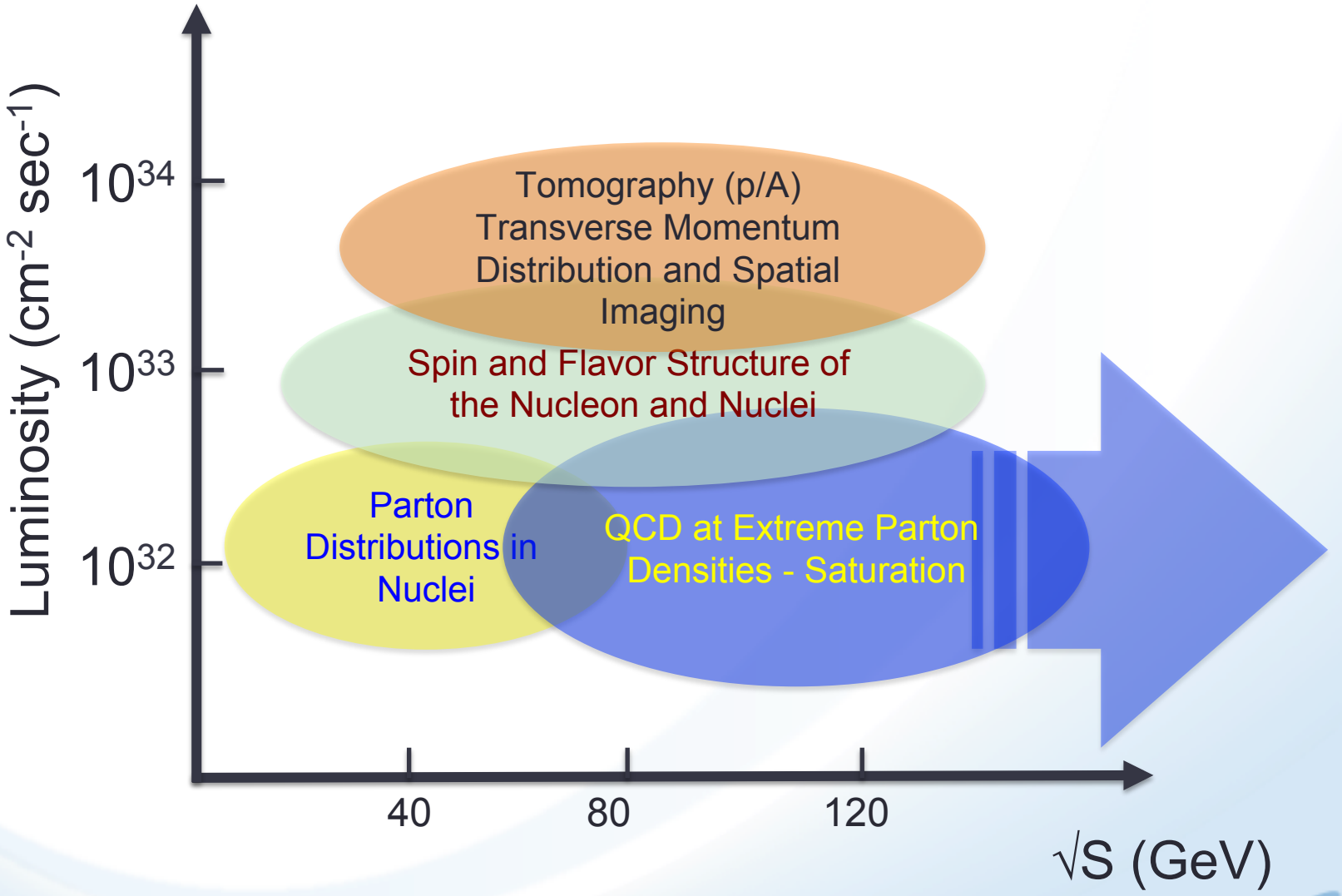
JLab



AGS

BNL

Physics vs. Luminosity & Energy



EIC Strategy

- 1st EIC Users Meeting at Stony Brook June 24-27, 2015
  - 180 participants
- EIC Users Group sign-up under way
- 2nd EIC Users Meeting at Berkeley January 6-9, 2016

- Collaboration with Cornell on eRHIC Prototype (Cβ)
  - $25M project with prospect for NY State funding

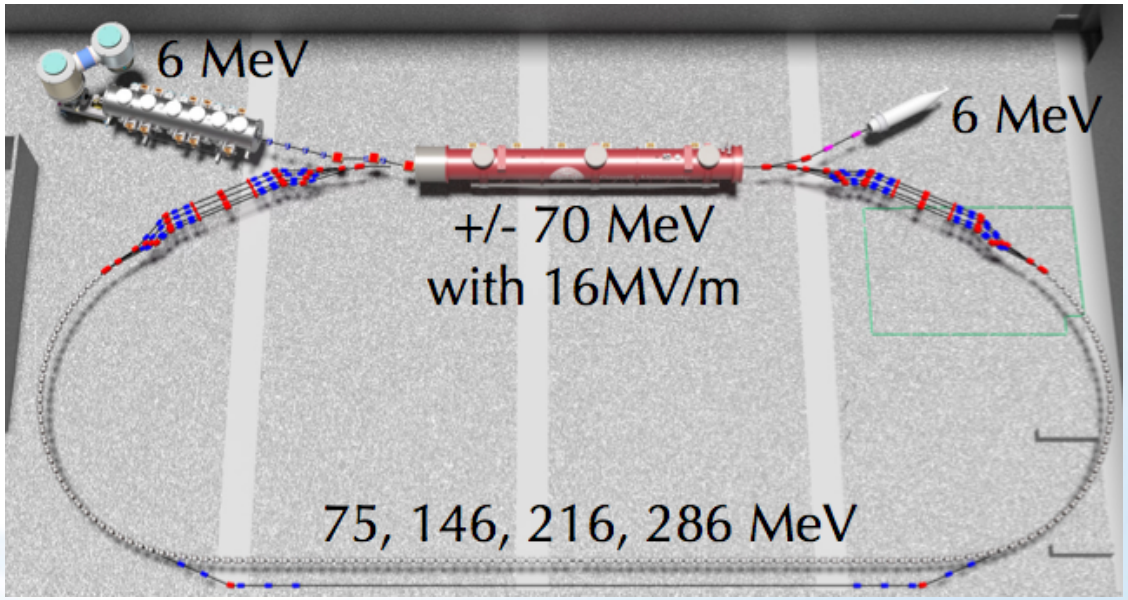
- eRHIC R&D Advisory Committee convened
  - Internal/external members (Chair: M. Harrison)
  - 1st meeting August 10, 2015
  - 2nd meeting November 19-20, 2015

Designing the "right" eRHIC

- Two basic options: Ring-ring, Linac-ring
  - "Ring" means storage ring (RHIC has two!)
  - Linac-ring has never been built before = technical risk
  - Ring-ring suffers from synchrotron radiation loss
  - Linac-ring uses each electron bunch once and requires ERL
- Main technical challenges
  - High efficiency hadron beam cooling for luminosity
  - High intensity polarized electron source
  - High energy multi-pass ERL (SRF challenges)
  - Low cost electron beam recirculation (FFAG)
  - High luminosity interaction regions with low radiation
- Technical performance risk must be balanced against performance goals and cost

Multi-pass test-ERL at Cornell

- Uses existing 6 MeV high-current injector and 70 MeV CW SRF Linac
- Will prove basic principles of linac-ring design for EIC:
  - ERL with single four-pass recirculation arc with x4 momentum range
  - Uses permanent magnets for recirculation arc
  - Test of spreader/combiner beam lines
  - Test of HOM damping of eRHIC accelerating cavity
- Completion in 2018/19 with NY State funds (?)



Why BNL?

Three basic reasons why BNL is the optimal site for the EIC:

1. eRHIC would have higher energy than the EIC option offered by JLab, which provides access to the whole range of EIC enabled science targeted in the Long Range Plan.

2. BNL can realize the same EIC capabilities as JLab, for significantly lower cost, because of the >$2B investment in the RHIC complex.

3. BNL has long and deep experience in all aspects of an EIC: acceleration and storage rings for electrons (NSLS, NSLS-II), polarized protons (RHIC), and heavy ions up to uranium (RHIC).

Summary

- RHIC is doing exceptionally well
- RHIC operations through BES-II seem assured
- sPHENIX progressing toward official project status
- New NSAC LRP provides an excellent basis for RHIC to eRHIC transition
- EIC community organization progressing well
- Search for optimal eRHIC design ongoing
- eRHIC R&D plan is firming up, but very challenging

- We can realize our ambitions if we stay focused and work effectively together – it will not be easy and require some sacrifices, but we can do it!

Other News

Other News

- FY 2015 was the safest year ever at BNL. Please keep breaking records!

- Instrumentation:
  - Unique resource of the Lab
  - Good progress on evolving business model
  - Critical involvement in many high priority areas of the Lab agenda

- Magnet Division:
  - Unique resource of the Lab
  - New business plan developed and submitted to LD's office
  - Strong Program Development support (~$4M over 4 years)

BNL Office of Institutional Improvement